NOAA SCIENTIFIC PUBLICATIONS REPORT

JULY 20, 2015

HIGHLIGHTED ARTICLES

Decadal acidification in the water masses of the Atlantic Ocean
PNAS (9.674)

Contrasting futures for ocean and society from different anthropogenic CO2 emissions scenarios
Science (31.48)

A scientific alternative to moratoria for rebuilding depleted international tuna stocks
Fish and Fisheries (8.258)

Stratosphere an accomplice for Santa Ana winds in California wildfires
Geophysical Research Letters (4.456)

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Location isn't everything: timing of spawning aggregations optimizes larval replenishment
PLOS ONE (3.534)

Comment on "Scope and compatibility of measures in international fisheries agreements" by Finus and Schneider
Oxford Economic Papers (0.846)

Anthropogenic subsidies and the shifting resource base of a generalist predator: implications for native prey
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Spatial and annual variation in fecundity and oocyte atresia of yellowtail flounder, Limanda ferruginea, in U.S. waters
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NWS Publications

[Orographically induced cirrus clouds in the lee of the southern Appalachian Mountains]
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[Global seasonal precipitation anomalies robustly associated with El Niño and La Niña events - an OLR perspective]
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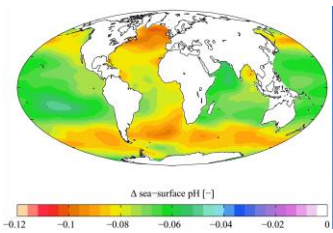
OTHER REPORTS, BOOK CHAPTERS, AND INTERNAL PUBLICATIONS

OAR Publications

[Chapter 121: The North American Great Lakes system]
The Hydrology Handbook





NOAA SCIENTIFIC PUBLICATIONS REPORT

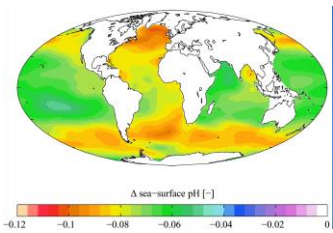
JULY 20, 2015

HIGHLIGHTED ARTICLES

Decadal acidification in the water masses of the Atlantic Ocean
PNAS (9.674)
A. F. Ríos, L. Resplandy, M. I. García-Ibáñez, N. M. Fajar, A. Velo, X. A. Padin, **R. Wanninkhof,** R. Steinfeldt, G. Roson, F. F. Pérez **(NOAA/AOML)**

- The largest decreases in pH were observed in central, mode, and intermediate Atlantic waters, with the largest decrease in South Atlantic Central Waters of $^{-}0.042 \pm 0.003$.
- There was very little to no change in pH in deep and bottom waters.
- Observations and model results show that pH changes are generally dominated by the anthropogenic component, which accounts for rates of between -0.0015 and -0.0020 yr-1 in the central waters

Global ocean acidification is primarily caused by the ocean's uptake of CO2 as a consequence of increasing atmospheric CO2 levels. We present observations of the oceanic decrease in pH at the basin scale (50ºS-36ºN) for the Atlantic Ocean over two decades (1993-2013). Changes in pH associated with the uptake of anthropogenic CO2 (ΔpHCant) and with variations due to biological activity and ocean circulation (ΔpHNat) are evaluated for different water masses. Output from an IPSL climate model is used to place the results into a longer-term perspective and to elucidate the mechanisms responsible for pH change. The largest decreases in pH (ΔpH) were observed in central, mode, and intermediate waters, with a maximum ΔpH value in South Atlantic Central Waters of $^{-}0.042 \pm 0.003$. ΔpH trended towards zero in deep and bottom waters. Observations and model results show that pH changes are generally dominated by the anthropogenic component, which accounts for rates of between -0.0015 and -0.0020 yr-1 in the central waters. The anthropogenic and natural components are of the same order of magnitude and reinforce one another in mode and intermediate waters over the time period. Large negative ΔpHNat values observed in mode and intermediate waters are primarily driven by changes in CO2 content and are consistent with: (1) a poleward shift of





the formation region during the positive phase of the Southern Annular Mode in the South Atlantic; and (2) an increase of the water mass formation rate in the North Atlantic.
Estimated publication date: July 2015

Contrasting futures for ocean and society from different anthropogenic CO2 emissions scenarios
Science (31.48)
J.-P. Gattuso, A. Magnan, R. Billé, W. W. L. Cheung, E. L. Howes, F. Joos, D. Allemand, L. Bopp, S. R. Cooley, **C. M. Eakin (NESDIS/STAR/SOCD/MECB)**, O. Hoegh-Guldberg, R. P. Kelly, H.-O. Pörtner, A. D. Rogers, J. M. Baxter, D. Laffoley, D. Osborn, A. Rankovic, J. Rochette, U. R. Sumaila, S. Treyer, C. Turley

- Impacts on key marine and coastal organisms and ecosystems from CO_2 emissions are already detectable across various latitudes, and several will face high risk of impacts well before 2100 even with stringent cuts in CO_2 emissions.
- Some of the greatest impacts are expected to be felt by coral reefs and bivalves, even if we keep the earth at 2°C of warming.

The ocean moderates anthropogenic climate change at the cost of profound alterations of its physics, chemistry, ecology, and services. Here, we evaluate and compare the risks of impacts on marine and coastal ecosystems—and the goods and services they provide—for growing cumulative carbon emissions under two contrasting emissions scenarios. The current emissions trajectory would rapidly and significantly alter many ecosystems and the associated services on which humans heavily depend. A reduced emissions scenario—consistent with the Copenhagen Accord's goal of a global temperature increase of less than 2°C—is much more favorable to the ocean but still substantially alters important marine ecosystems and associated goods and services. The management options to address ocean impacts narrow as the ocean warms and acidifies. Consequently, any new climate regime that fails to minimize ocean impacts would be incomplete and inadequate.

Publication Date: July 3, 2015
Available online: http://www.sciencemag.org/content/349/6243/aac4722.abstract

A scientific alternative to moratoria for rebuilding depleted international tuna stocks

Fish and Fisheries (8.258)

R. M. Hillary, A. L. Preece, C. R. Davies, H. Kurota, O. Sakai, T. Itoh, A. M. Parma, D. S. Butterworth, **J. Ianelli**, and T. A. Branch **(NMFS/AKFSC)**

- Illustrates a successful implementation of management strategy evaluation (MSE) in a tense international arena.
- Extensive stakeholder involvement in developing rebuilding strategy while maintaining agreed objectives for the fishery.

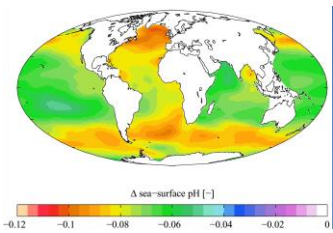
There is considerable international concern and scientific debate about the current state and future of tuna stocks worldwide and the capacity of Regional Fisheries Management Organisations to manage the associated fisheries effectively. In some cases, this concern has extended to predictions of imminent collapse with minimal chances of recovery, even under a commercial catch moratorium. As a viable alternative to a full fishery closure, the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) adopted a scientifically tested, adaptive rebuilding strategy for the depleted southern bluefin tuna (*Thunnus maccoyii*) stock. The management procedure (MP) they adopted involves a harvest control rule that fully specifies the total allowable catch as a function of key indicators of stock status, and adjusts future harvest levels every three years so as to meet the rebuilding targets agreed by CCSBT. This MP was chosen from a subset of candidate MPs that were selected following extensive simulation testing. Simulation testing involved first selecting a wide range of plausible scenarios for stock status and input data, ranging from pessimistic to optimistic, against which the alternative candidate MPs were tested to ensure that they were robust to important uncertainties. This study represents the first time that a comprehensively evaluated MP has been adopted for an internationally managed tuna stock. Both

the process and the outcomes have broad applicability to other internationally managed stocks.
Expected publication date: June 2015
Available online: http://onlinelibrary.wiley.com/doi/10.1111/faf.12121/epdf

Stratosphere an accomplice for Santa Ana winds in California wildfires
Geophysical Research Letters (4.456)
A. O. Langford (OAR), R.B. Pierce (NESDIS), and P.J. Schultz (OAR/CI)

- This paper shows that intrusions of dry air from the stratosphere to the Earth's surface likely contributed to the fire danger in California's 2013 Springs Fire.
- The findings suggest that forecast models with the capacity to predict stratospheric intrusions may provide valuable lead time for agencies to issue air quality alerts and fire weather warnings or to reallocate fire fighting resources before these extreme events occur.

The Santa Ana winds of southern California have long been associated with wildland fires that can adversely affect air quality and lead to loss of life and property. These katabatic winds are driven primarily by thermal gradients, but can be exacerbated by northerly flow associated with upper level troughs passing through the western U.S. The authors showed how the fire danger associated with the passage of upper level troughs can be further increased by the formation of deep tropopause folds that transport extremely dry ozone-rich air from the upper troposphere and lower stratosphere to the surface. Stratospheric intrusions can thus increase surface ozone both directly through transport, and indirectly through their influence on wildland fires. These methods are illustrated using the example of the Springs fire, which burned nearly 25,000 acres in Ventura County during May 2013.
Accepted: 3 July 2015
Available online:
http://onlinelibrary.wiley.com/doi/10.1002/2015GL064964/full?campaign=wlytk-41855.5282060185





ADDITIONAL ARTICLES

NMFS Publications

Location isn't everything: timing of spawning aggregations optimizes larval replenishment

PLOS ONE (3.534)

M. J. Donahue, **M. Karnauskas**, C. Toews, C. B. Paris **(NMFS/SEFSC)**

- Using a highly realistic biophysical model of ocean currents and larval behavior we traced the movement of snapper larvae from spawning sites in northwest Cuba to settlement on reefs throughout the region.
- We found that larval success was sensitive to the timing of spawning – in particular, larval success was higher on days when spawning is observed to occur, compared to other days.
- The results suggest that if existing spawning aggregations are fished out, spawning populations may form at new spatiotemporal locations that have lower reproductive success and are less optimal for population sustainability

Many species of reef fishes form large spawning aggregations that are highly predictable in space and time. Prior research has suggested that aggregating fish derive fitness benefits not just from mating at high density but, also, from oceanographic features of the spatial locations where aggregations occur. Using a probabilistic biophysical model of larval dispersal coupled to a fine resolution hydrodynamic model of the Florida Straits, we develop a stochastic landscape of larval fitness. Tracking virtual larvae from release to settlement and incorporating changes in larval behavior through ontogeny, we found that larval success was sensitive to the timing of spawning. Indeed, propagules released during the observed spawning period had higher larval success rates than those released outside the observed spawning period. In contrast, larval success rates were relatively insensitive to the spatial position of the release site. In addition, minimum (rather than mean) larval survival was maximized during the observed spawning period, indicating a reproductive strategy that minimizes the probability

of recruitment failure. Given this landscape of larval fitness, we take an inverse optimization approach to define a biological objective function that reflects a tradeoff between the mean and variance of larval success in a temporally variable environment. Using this objective function, we suggest that the length of the spawning period can provide insight into the tradeoff between reproductive risk and reward.

Expected publication date: June 23, 2015

Online version:

http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0130694

Comment on "Scope and compatibility of measures in international fisheries agreements" by Finus and Schneider

Oxford Economic Papers (0.846)

D. Squires (NMFS/SWFSC), **L. T. Balance (NMFS/SWFSC)**, R. Deriso, **J. Ianelli (NMFS/AKFSC)**, M. Maunder, and K. Schaefer

- Raises issues and inconsistencies with the game-theoretic approach applied to a bioeconomic model in an earlier paper; namely:
- Fish movements are unreasonably depicted
- The method for estimating MEY and associated biomass using a poorly specified production technology

"Scope and compatibility of measures in international fisheries agreements" uses game theory and bioeconomic modelling to break important ground and provides a real contribution to the economics of international fisheries agreements (IFAs). In this comment we wish to raise two issues relevant to the modelling framework used in the article that is one widely adopted in this area. The first is whether the model's fish movements, specified by a diffusion parameter, accurately portray fish movements. We argue that the biological evidence does not support the assumptions made in the article for many, possibly most fish species. The second is the specification of production technology in the model giving maximum economic yield (MEY) and corresponding resource stock (BMEY). We argue that the assumptions made in the article are not consistent with current practice and

empirical evidence. Specifications inconsistent with actual fisheries can give misleading advice, such as closing off large sections of the high seas, which, instead of increasing populations, yields, and rents, decreases them.
Expected publication date: June 22, 2015
Online Version: doi: 10.1093/oep/gpv041

Anthropogenic subsidies and the shifting resource base of a generalist predator: implications for native prey
Biological Conservation (4.036)
A.-M. K. Osterback, D. M. Frechette, **S. A. Hayes**, S. A. Shaffer, J. W. Moore **(NMFS/SWFSC)**

- A comparison of isotopically based food-web signatures indicated Western Gulls have shifted their diet over the past 100 years, to human based food sources (dumps).
- This has likely allowed for population growth and increased predation pressure on imperiled prey species like ESA listed salmonids.

Over the last century, human activities have altered coastal ecosystems by fishing through the marine food web and increasing anthropogenic resources (e.g. landfills), both of which may alternative predator-prey interactions. We conducted a 100-year retrospective stable isotope analysis to investigate temporal shifts in relative resource use and individual variation of a generalist seabird (Western Gull, *Larus occidentalis*) and the implications of gulls` shifting resource use on one of their native prey—threatened steelhead populations (*Oncorhynchus mykiss*). We applied a Bayesian mixing model (MixSIAR) to historical (early 1900s) and modern (early 2000s) populations of generalist gulls and compared changes in resource use to a piscivorous seabird population (Brandt's Cormorant, *Phalacrocorax penicillatus*) in Monterey Bay (California, USA). δ15N significantly declined for both seabird species, suggesting shifts to lower trophic level marine prey in the last 100 years. The shift in δ15N was significantly larger for Western Gulls, suggesting a shift in gull resource use to prey not in the marine environment. Mixing models suggest anthropogenic resources (e.g., landfills)

comprise the majority of modern gull diet (0.31; 0.18-0.44 95% CI), whereas it contributed relatively little to gull diet in the early 1900s (0.10; 0.01-0.26 CI). Furthermore, we found although steelhead contribute relatively less to overall modern gull diet, increasing gull populations and simultaneous steelhead population decline likely results in ~2.4 times higher per capita predation risk to modern steelhead populations. This study highlights the impact of human activities on coastal predators and the potential consequences for native imperiled prey.
Expected Publication Date: Summer/Fall 2015

Spatial and annual variation in fecundity and oocyte atresia of yellowtail flounder, Limanda ferruginea, *in U.S. waters*

W. D. McElroy, **M. J. Wuenschel**, E. K. Towle, **R. S. McBride (NEFSC)**

- Fecundity of yellowtail flounder was estimated for three stocks off the NE U.S.
- Positive allometry in fecundity at female size was evident, and fecundity and intensity of down-regulation was variable among stocks and years and related to fish condition.
- Spatial differences were found in fecundity estimates, with fish from southern New England fish more fecund at size than fish from the Gulf of Maine.

Potential annual fecundity (PAF) was estimated over three years (2010-2012) for yellowtail flounder with individuals from the three stocks off the northeast U.S. coast. The resorption of oocytes during development, known as down-regulation, was evident as the vitellogenic cohort advanced, so the authors directly measured atresia of vitellogenic oocytes using stereological techniques. PAF models including relative fish condition, stock area, year, and oocyte diameter of the leading cohort explained more variation than models with just size alone. In a given year, Gulf of Maine females had lower PAF at size than southern New England females. Interannual differences were also evident: PAF of both stocks was higher in 2010 and lower in 2012, with 2011 showing less synchronization between stocks. Differences in size at age and relative condition suggested that

energy available for somatic and reproductive growth was lower in some years in the Gulf of Maine and Georges Bank, especially 2011. Georges Bank PAF and condition were intermediate to the other stocks or more similar to the Gulf of Maine, varying annually. The magnitude of down-regulation was variable across stocks and typically 3-25% of PAF. This was accounted for in fecundity estimates by the seasonal schedule of sampling and use of an oocyte diameter term in the fecundity model. Theoretical models of atresia patterns suggested variable rates over the later portion of clutch development. The timing of down-regulation varied among years, and its intensity was influenced by female relative condition. Fecundity was related to fish size, but was also affected by fish condition and oocyte diameter (a proxy for time until spawning), and spatial and temporal effects. A longer time series of PAF may identify environmental drivers that modulate annual stock reproductive potential.
Acceptance date: 24 June 2015

Chinook salmon outmigration survival in wet and dry years in California's Sacramento River
Canadian Journal of Fish and Aquatic Sciences (2.276)
C. J. Michel, A. J. Ammann, S. T. Lindley, P. T. Sandstrom, E. D. Chapman, M. J. Thomas, G. P. Singer, A. P. Klimley, **R. B. MacFarlane (NMFS/SWFSC)**

- Survival in the Sacramento River is quite low compared to other large west-coast rivers like the Columbia River
- Survival in the Sacramento River increases with higher flows
- High mortality occurs in the delta as well as other areas.

Outmigration survival of acoustic tagged hatchery-origin Sacramento River late-fall run Chinook salmon (*Oncorhynchus tshawytscha*) smolts was estimated for five years (2007-2011) using a receiver array spanning the entire outmigration corridor, from the upper river, through the estuary, and into the coastal ocean. The first four years of releases occurred during below-average river flows, while the fifth year (2011) occurred during above-average flows. In 2011, overall

outmigration survival was two to five times higher than survival in the other four years. Regional survival estimates indicate that most of the improved survival seen in 2011 occurred in the riverine reaches of the outmigration corridor, while survival in the brackish portions of the estuary did not significantly differ among the five years. For the four low flow years combined, survival rate in the river was lower in the more anthropogenically-modified upper reaches; however, across all regions, survival rate was lowest in the brackish portion of the estuary. Even in the high flow year, outmigration survival was substantially lower than yearling Chinook salmon populations in other large rivers. Potential drivers of these patterns are discussed, including channelization, water flow, and predation. Finally, management strategies are suggested to best exploit survival advantages described in this study.
Accepted: 13 June 2015

The invasion of an Atlantic Ocean river basin in Patagonia by Chinook salmon: new insights from SNPs
Biological Invasions (2.586)
J. E. Ciancio, C. R. Rossi, M. Pascual, **E. Anderson** and **J. C. Garza** **(NMFS/SWFSC)**

- The authors used genetic stock identification with single nucleotide polymorphisms to explore the origin of the Chinook salmon population in the Santa Cruz River Basin of Patagonia.
- This salmon population was found to be most similar to those from the lower Columbia River. This supports the hypothesis that the Santa Cruz River population was founded from the ocean ranching in southern Chile and the river was invaded by fish straying from Pacific coast basins.

Chinook salmon spawning was first reported in the 1980s in the Caterina River tributary of the Santa Cruz River basin of Patagonia, which drains into the Atlantic Ocean. A naturalized population now persists and its source has been debated. Chinook salmon from California populations was directly released into the Santa

Cruz River in the early twentieth century, but ocean ranching experiments on the Pacific coast of Patagonia (Chile) also released Chinook salmon of lower Columbia River origin University of Washington hatchery stock) in the late twentieth century. The genotypes of salmon that invaded the Santa Cruz River were compared with those derived from 69 known populations from the Northern Hemisphere. Chinook Salmon of the Santa Cruz River were found to be most similar to those from the lower Columbia River. This supports the hypothesis that the Santa Cruz River population was founded from the ocean ranching in southern Chile and the river was invaded by fish straying from Pacific coast basins. Moreover, this study finds that the life history of these naturalized fish, as inferred from scale analysis, was similar to that of the progenitor stock. The authors suggest that the successful invasion of the Caterina River in Patagonia by Chinook salmon was aided by pre-adaptations of some of the stocks used in the ocean ranching experiments to conditions in the new environment, rather than a post-colonization adaptation. A definitive assessment of the origin of the colonizing salmon in the Santa Cruz River of Patagonia found that it was from the potential donor stock with the most appropriate life history strategy for the invaded basin.
Accepted: June 2015

NWS Publications

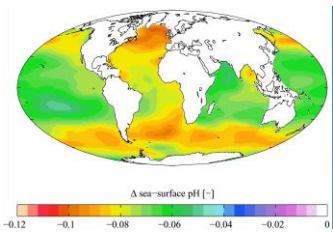
Orographically induced cirrus clouds in the lee of the southern Appalachian Mountains

Journal of Operational Meteorology

R. Ellis, J. Blaes, and L. Anderson **(NWS/WFO-Raleigh, NC)**

- This study provides better understanding of the reasons for orographic cirrus development in the lee of the Southern Appalachian Mountains.
- This study should lead to better forecasts and warnings from the NWS in the lee of the Southern Appalachian Mountains.

The development of orographically induced cirrus clouds east of the southern Appalachian Mountain chain can result in areas of unanticipated cloudiness downstream from the higher terrain across the Carolinas and Virginia. Both the





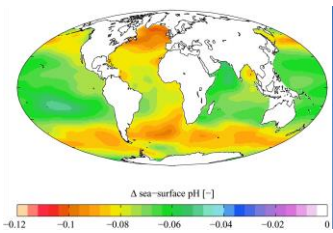
degree of cloudiness and its impact on surface temperatures can have an adverse impact on forecast accuracy. This study will attempt to quantify the conditions necessary for orographic cirrus development near and downstream of the southern Appalachian Mountains. This study evaluates null events of orographic cirrus when atmospheric conditions are conducive for cirrus development but none occurs. A case study is presented from October 2008 illustrating a classic orographic cirrus event and its impacts on local forecast variables.
Expected Publication Date: Summer 2015

OAR Publications

Global seasonal precipitation anomalies robustly associated with El Niño and La Niña events - an OLR perspective
Journal of Climate (4.904)
A. M. Chiodi and **D. E. Harrison (OAR/PMEL)**

- It is historically necessary to wait until northern hemisphere autumn to identify OLR-based events with confidence, but the 2015 El Niño has the initial markers of the first OLR-El Niño event since 1997-1998.

El Niño-Southern Oscillation (ENSO) events are associated with particular seasonal weather anomalies in many regions around the planet. When the statistical links are sufficiently strong, ENSO state information can provide useful seasonal forecasts with varying lead times. However, using conventional sea surface temperature or sea level pressure indices to characterize ENSO state leads to many instances of limited forecast skill (e.g,. years identified as 'El Niño' or 'La Niña' with weather anomalies unlike the average) even in regions where there is considerable ENSO-associated anomaly, on average. We show here that using outgoing longwave radiation (OLR) conditions to characterize ENSO state identifies a subset of the conventional ENSO years, which we call OLR El Niño and OLR La Niña years. We demonstrate that treating the OLR-identified subset of years differently can usefully strengthen both the level of statistical significance in the average (composite) and also greatly reduce the year-to-year deviations in the



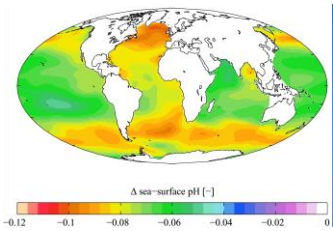


composite precipitation anomalies. On average, over most of the planet, the non-OLR El Niño and non-OLR La Niña years have much more limited statistical utility for precipitation. The OLR El Niño and OLR La Niña indices typically identify years in time to be of use to boreal wintertime and later seasonal forecasting efforts, meaning that paying attention to tropical Pacific OLR conditions may offer more than just a diagnostic tool. Understanding better how large-scale environmental conditions during ENSO events determine OLR behavior (and deep-atmospheric convection) will lead to improved seasonal precipitation forecasts for many areas.
Expected Publication Date: Summer 2015
Available online: http://journals.ametsoc.org/doi/abs/10.1175/JCLI-D-14-00387.1

Mapping the global dust storm records: review of dust data sources in supporting modeling/climate study
Current Pollution Reports (NA)
J. Wang (OAR/ARL)

- This review will focus on currently available observations of dust activities, which include routine meteorological records, in situ air chemistry observations, and satellite remote sensing.
- The aim is to show data sources and the status of their usage in a common framework for global dust regions.

Dust storms, as extreme environmental events, are one of the Earth's major natural hazards. Their impact on socio-economics can range from local urban to (trans-) continental and from minutes to decades, such as the dust bowl of the 1930s in the United States. Research on dust storms can be traced back for several decades as a meteorological extension. The latest technology developments have enabled comprehensive studies on dust storms, including sampling improvement, analytic studies, and numerical modeling. However, inhomogeneity of the data has hampered and sometimes even misguided research on comprehensive understanding of dust storms and exploring their feedbacks with climate. This review will focus on currently available observations of dust activities, which





include routine meteorological records, in situ air chemistry observations, and satellite remote sensing. The aim is to show data sources and the status of their usage in a common framework for global dust regions. Emphasis is placed on data continuity and the spatial and temporal coverage of dust storms, since it is anticipated that this brief summary of dust data will benefit modeling and climate studies. Therefore, it must be noted that field campaign data are outside of the scope of the current review, although they play an important role in research and understanding.
Expected Publication: June 2015

NESDIS Publications

A 2015 International Geomagnetic Reference Field (IGRF) candidate model based on Swarm's experimental absolute magnetometer vector mode data
Earth Planets Space (3.056)
P. Vigneron, G. Hulot, N. Olsen, J-M. Leger, T. Jager, L. Brocco, O. Sirol, P. Coisson, X. Lalanne, **A. Chulliat** , F. Bertrand, A. Boness, and I. Fratter **(NESDIS/NCEI)**

- A candidate model to the 12th International Geomagnetic Reference Field was successfully calculated from an experimental magnetometer providing both scalar and vector measurements of the Earth's magnetic field.
- Shows how the new ASM instrument could be used in future magnetic satellite missions. This instrument would reduce the payload size and simplify instrument calibration.

Each of the three satellites of the European Space Agency *Swarm* mission carries an absolute scalar magnetometer (ASM) that provides the nominal 1-Hz scalar data of the mission for both science and calibration purposes. These ASM instruments, however, also deliver autonomous 1-Hz experimental vector data. Here, we report on how ASM-only scalar and vector data from the Alpha and Bravo satellites between November 29, 2013 (a week after launch) and September 25, 2014 (for on-time delivery of the model on October 1, 2014) could be used to build a very valuable candidate model for the 2015.0 International Geomagnetic Reference

Field (IGRF). A parent model was first computed, describing the geomagnetic field of internal origin up to degree and order 40 in a spherical harmonic representation and including a constant secular variation up to degree and order 8. This model was next simply forwarded to epoch 2015.0 and truncated at degree and order 13. The resulting ASM-only 2015.0 IGRF candidate model is compared to analogous models derived from the mission's nominal data and to the now-published final 2015.0 IGRF model. Differences among models mainly highlight uncertainties enhanced by the limited geographical distribution of the selected data set (essentially due to a lack of availability of data at high northern latitude satisfying nighttime conditions at the end of the time period considered). These appear to be comparable to differences classically observed among IGRF candidate models. These positive results led the ASM-only 2015.0 IGRF candidate model to contribute to the construction of the final 2015.0 IGRF model.
Published: 20 June 2015
Available online: http://link.springer.com/article/10.1186%2Fs40623-015-0265-4

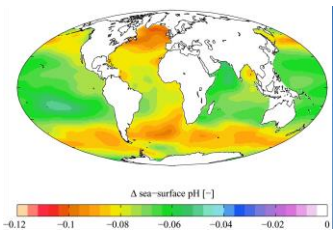
OTHER REPORTS, BOOK CHAPTERS, AND INTERNAL PUBLICATIONS

OAR Publications

Chapter 121: The North American Great Lakes system
The Hydrology Handbook
A.D. Gronewold (OAR/GLERL)

- A synopsis of the Great Lakes hydrological system is provided for an update to hydrology's benchmark reference book.
- Provides comprehensive coverage of the current state of hydrologic knowledge and practice.
- The Handbook of Hydrology includes the contributions of more than 50 international authorities, and this chapter will highlight NOAA's efforts in the Great Lakes.

An introduction to the Great Lakes hydrological system. The North American Great Lakes system is commonly defined, as shown in figure 121-1, as the





international waters of the Great Lakes themselves (i.e. Lakes Superior, Michigan, Huron, Erie, and Ontario), the rivers that connect them (commonly referred to as `interconnecting channels'), and their surrounding drainage areas. Generally, water flows through the system from Lake Superior through the St. Marys River, as shown in figure 121-2, to Lake Michigan-Huron (Lake Michigan and Lake Huron are often considered one lake because of their connection at the Straits of Mackinac). From Lake Huron, water flows through the St. Clair River, through Lake St. Clair, and through the Detroit River into Lake Erie. Water then flows out of Lake Erie through the Niagara River and over Niagara Falls into Lake Ontario. The downstream boundary of the Great Lakes is often defined as the outlet of Lake Ontario, as reflected in figure 121-1. However, the downstream boundary of the Great Lakes system is also sometimes defined by the Moses-Saunders dam (the point at which outflows from Lake Ontario are regulated), located along the St. Lawrence River at Cornwall, Ontario (Canada) and Massena, NY (USA). For further reading on the St. Lawrence River system downstream of the Great Lakes, see Chapter 113. The Great Lakes constitute the largest (both by volume and surface area) system of lakes on Earth (Herdendorf, 1990; Quinn, 1992). Lake Michigan-Huron alone has the largest continuous surface area (117,250 km2) of any freshwater surface body on Earth, while Lake Superior has the second largest surface area (82,100 km2). The total volume of the Great Lakes (roughly 22,800 km3) is very close to the volume of Lake Baikal, Earth's largest lake by volume (roughly 23,000 km3), and is slightly larger than that of Lake Tanganyika (18,900 km3). Together, these three systems (the Great Lakes, Lake Tanganyika, and Lake Baikal) comprise about half of all of the fresh surface water on Earth.